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# VALENS RESERVOIR CHLORINATION STUDY

TECHNICAL BULLETIN 5-74

October 1974

Ministry
of the
Environment

Ontario

The Honourable
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Minister

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Deputy Minister

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# VALENS RESERVOIR CHLORINATION STUDY

TECHNICAL BULLETIN 5-74

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# SUMMARY

In-situ acute toxicity tests were conducted at Valens Reservoir, Wentworth County, to evaluate the potential hazard to aquatic life through the chlorination of a public swimming area. The area was partially enclosed by a polyester barrier extending along the offshore periphery of the chlorinated sector.

Caged amphipods (*Hyalella azteca*) were placed outside the barrier and their survival was observed following a series of chlorine applications yielding maximum residuals of 2 - 4 mg/l of free chlorine. With the exception of one site where a gap in the barrier permitted the outflow of treated water, no significant toxicity was detected as compared to the control site. The findings of this study suggest that total containment of chlorinated waters within natural or impounded waterbodies, through the use of properly installed impermeable barriers, should afford adequate protection to the biological communities of the open-water areas.

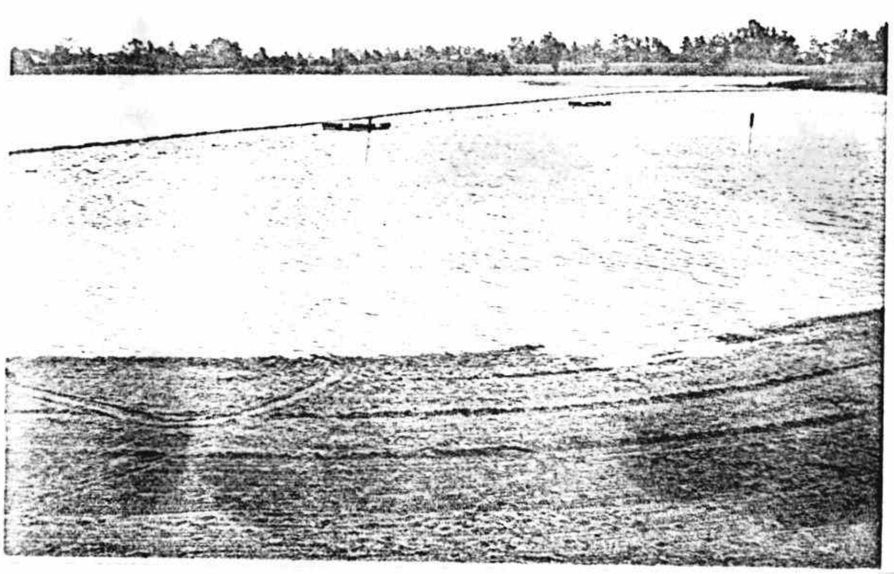
# INTRODUCTION

While use of chlorine is a well-established practice in a number of industrial and municipal applications, its role as a surface water contaminant has not always been well-defined and understood. Numerous recent publications dealing with residual chlorine toxicity (Arthur and Eaton 1971, Zillich 1972, Brungs 1973, Martens and Servizi 1974) provide useful reference material for assessing potential hazards to aquatic life, however, the highly complex nature of residual chlorine formation and persistance makes interpretation difficult especially under variable field conditions.

To evaluate the effectiveness of open-water chlorination and potential side-effects on aquatic life, the Ministry of Environment proposed an experimental programme to monitor chlorination activities undertaken by the Hamilton Region Conservation Authority at Valens Reservoir. Chlorination of the swimming area at Valens was suggested as a management tool to control bacterial levels and occurrences of swimmers itch during periods of peak utilization.

While other Sections of the Ministry were involved in monitoring chemical and microbiological parameters, a series of toxicity studies were conducted by the Toxicity Unit to estimate the impact on aquatic life associated with the chlorination programme. Caged amphipods (*Hyalella azteca*) were introduced at the periphery of the chlorinated area and their survival observed.

VIEW OF THE SWIMMING AREA AND BARRIER



## THE STUDY AREA

Valens Reservoir is situated approximately 85 kilometers southwest of Toronto bordering on highway #97, east of Galt. Most of the drainage area consists of gently rolling farm land, except for a marshy area in the northerly section of the park which is maintained as a wildlife refuge by the Authority. The reservoir has a surface area of approximately 75 hectares (187 acres), with an average depth of 2 meters. Dense vegetation was found in the littoral zones of the lake, consisting mainly of *Myriophyllum sp.*, *Chara sp.*, *Najas flexilis*, and *Ceratophyllum sp.* Lake sediments were found to be highly organic in all areas with the exception of sandy gravel in the beach area. The approximate volume in the enclosed swimming area was estimated to be about 1,278,125 gallons, enclosed by a polyester barrier curtain.

## PHYSICAL AND CHEMICAL PARAMETERS

Test sites selected were approximately of the same depth (1.8 meters) and all were located close to areas of heavy vegetation.

The physico-chemical parameters of the study area are summarized in Table 1. All chemical analyses were performed at the Ministry's Laboratories in Rexdale except for pH, temperature and dissolved oxygen, all of which were performed in the field.

## METHODS AND MATERIALS

Test containers consisted of cylindrical polycarbonate jars, 25 cm. high and 20 cm. in diameter, with two sections in the wall removed to facilitate water exchange. The openings were covered by Nytex nylon monofilament bolting cloth #423 to contain test organisms (Figure 1).

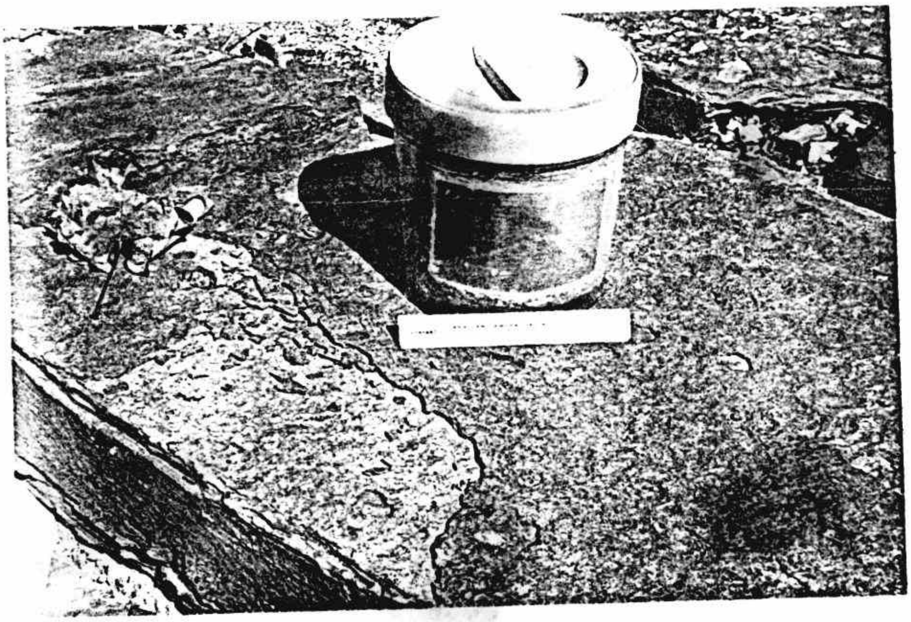


Figure 1

All containers were suspended at a depth of one meter below the surface by means of an anchor and a submerged float.

Two test jars with ten amphipods each were placed at each test site, utilizing a common anchor and float.

Amphipods (Hyalella aztecta) native to Valens Reservoir, and ranging from 5 - 7 mm. in length, were placed randomly in test chambers, accompanied by sections of bushy pondweed (Najas flexilis) to provide shelter and food.

Each test series was introduced at least 24 hours before the first chlorine application. Since test organisms were obtained locally from an upstream location at Valens, no further acclimation was undertaken.

While a number of test sites were originally planned for the study, repeated losses of equipment imposed restrictions on site selection, consequently only two test sites were retained near the beach area in addition to a control further upstream. Station #5 was placed approximately midway along the barrier wall, while #6 was situated at the southern extremity of the swimming area. Both stations were approximately 25 meters outside the barrier wall. The control station #10 was located approximately 400 meters upstream, northwest from the beach area.

Three independent series of tests were conducted between August 2 and August 29, obtaining data for 72 hour, 96 hour, and 168 hour exposures. During the test periods, temperature, dissolved oxygen, and pH measurements were made in situ utilizing a model 57 YSI oxygen meter and Porto-matic pH meter. Survival of amphipods was observed at the end of each test period and expressed as per cent survival. Toxicity data obtained for the 72 hour and 96 hour exposure periods reflect two independent chlorine applications, whereas the 168 hour exposure incorporates the whole treatment cycle -- three times weekly.

Calcium hypochlorite 70% active was applied in the enclosed swimming area and mixed with an outboard motor to achieve uniform dispersion. Concentrations ranging from 2 - 4 mg/l of free chlorine were attained shortly after application.

# RESULTS AND DISCUSSION

The results of three independent toxicity tests of varying exposure times are summarized in Table #2. Amphipod survival at stations #5 and #10 was similar in all three exposures, ranging from 85% to 100%, whereas survival at station #6 was consistantly lower (5% - 35%). Absence of good reference material for Hyalella azteca as well as unavailability of satisfactory analytical methods for residual chlorine determinations have made interpretation of study results difficult. However, the high mortality rate at station #6 does indicate the presence of adverse conditions, likely associated with the chlorination activity. This observation is supported by the fact that basic water chemistry data, with the exception of residual chlorine, were similar at all stations (Table 1). Field measurements indicate that water temperature ranges and dissolved oxygen levels were suitable for amphipod survival at all test sites (Sprague 1973).

Amphipod mortality at station #6 was most likely related to the proximity of the containers to the openings in the barrier wall at the southern extremity of the beach area (Figure 2).

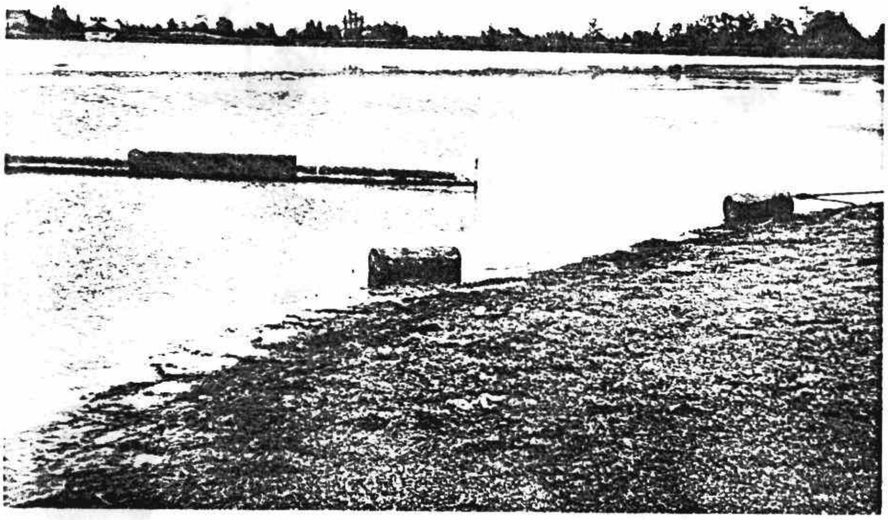


Figure 2

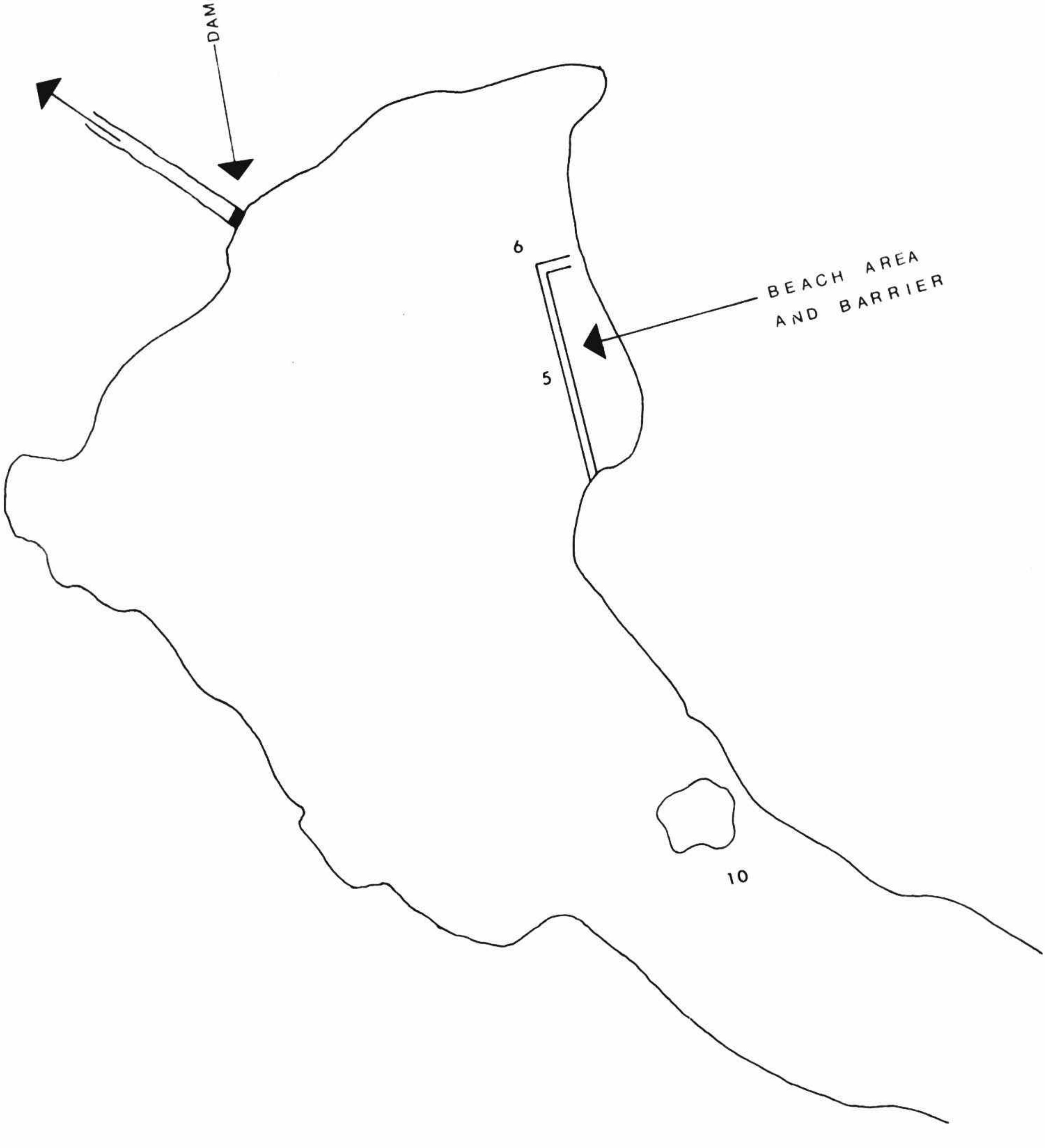
Visual inspection at this site revealed a constant discharge of water during periods when west and southwest winds predominated. These are the prevailing wind directions in this locatlity, therefore regular losses of chlorinated water can be expected near station #6. While no young were observed at either one of the stations located near the chlorinated area, hatching and survival of young amphipods at the control site (#10) was likewise suggestive of water quality impairment. This occurrence could have been circumstantial since no separation of gravid females was practiced when introducing organisms to the test containers.

Use of Gammarus pseudolimnaeus may have been preferable in view of the existing data for chloramine toxicity (Arthur and Eaton 1971), however, consistently high water temperatures during the chlorination period made its use impractical for this study. Due to its wide distribution and relatively high tolerance to adverse oxygen and temperature conditions, Hyalella azteca should be recognized as a potentially useful test organism for field studies, especially where flexibility of test systems is desirable.

The study has shown that acute toxicity was limited to station #6 only. This condition was apparently associated with the outflow of chlorinated water via the opening in the barrier wall. Good amphipod survival at station #5, adjacent to a section of intact barrier, indicates that chlorine residues were effectively contained within the swimming area. A survey of bottom fauna at the reservoir dam revealed a good variety of aquatic organisms, including numerous amphipods, suggesting a satisfactory water quality at the point of discharge.

To summarize, water quality impairment associated with the chlorination activity was minimal indicating that proper use of an impervious, vinyl-coated polyester barrier can effectively contain residual chlorine within an enclosed area, providing proper installation procedures are followed. However, the results of this study should not be construed as a suitable basis on which to implement long-term chlorination programmes for the management of public swimming areas. Since the high toxicity of chlorine to aquatic life is well documented, and the integrity of barriers cannot be assured under all conditions, the technique should only be employed where and when hazards to health have been confirmed by a competent medical authority, and where the effectiveness of a barrier has been demonstrated.

# APPENDIX



VALENS RESERVOIR - 1974

CAGED AMPHIPOD STATIONS

# TABLE 1

(All values except pH, temperature and conductivity shown
as milligrams per liter)

| | Control | | Station #1 | | Station #2 | |
|---|---|---|---|---|---|---|
| | Range | Mean | Range | Mean | Range | Mean |
| Total Suspended Solids | < 10 | < 10 | | < 10 | | < 10 |
| Total Dissolved Solids | 150-210 | 180 | | 210 | | 200 |
| Total Kjeldahl | .66-.71 | .69 | | .77 | | .61 |
| Free Ammonia (N) | .03-.06 | .05 | | <.01 | | <.01 |
| Total Phosphorus (P) | .020-.028 | .024 | | .046 | | .033 |
| Sodium (Na) | 2.6-2.8 | 2.7 | | 2.7 | | 2.5 |
| Chloride (Cl$^-$) | 5.8-6.2 | 6.0 | | 5.6 | | 5.7 |
| Potassium (K) | 1.7 | 1.7 | | 1.4 | | 1.4 |
| Calcium (Ca) | 19-20 | 20 | | 24 | | 24 |
| Hardness ($CaCO_3$) | 138 | 138 | | 145 | | 145 |
| Alkalinity ($CaCO_3$) | 119-120 | 120 | | 122 | | 123 |
| Conductivity (Micromhos) | 233-248 | 240 | | 260 | | 263 |
| pH | 9.6-9.7 | 9.7 | 9.0-9.1 | 9.1 | | 8.8 |
| Dissolved Oxygen | 10.2-11.1 | 10.6 | 6.9-8.2 | 7.5 | | 6.6 |
| Temperature ($^{\circ}$C) | 22.5-25.0 | 23.8 | 23.0-25.5 | 24.3 | | 23.8 |

## TABLE 2

## AMPHIPOD SURVIVAL SUMMARY
## VALENS RESERVOIR FIELD BIOASSAYS

| | 72 Hrs. | 96 Hrs. | 168 Hrs. |
|---|---|---|---|
| Control Station #10 | 95% | 95% | 95% |
| Station # 6 | 5% | 35% | 10% |
| Station # 5 | 85% | 95% | 100% |

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